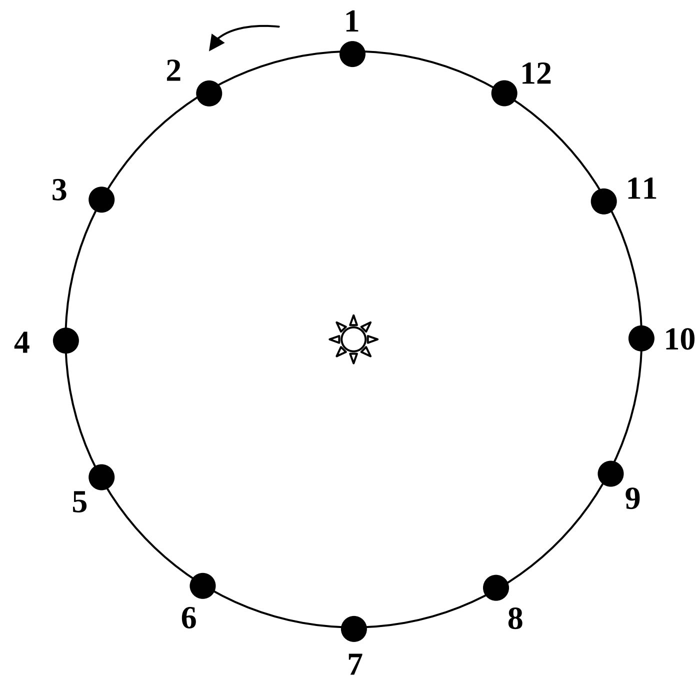
Kepler's Second Law (Preliminary Edition)

I. Equal Area in Equal Time Intervals

Kepler's Second Law of Planetary Motion states that a line joining a planet and the Sun sweeps out equal amounts of area in equal intervals of time.

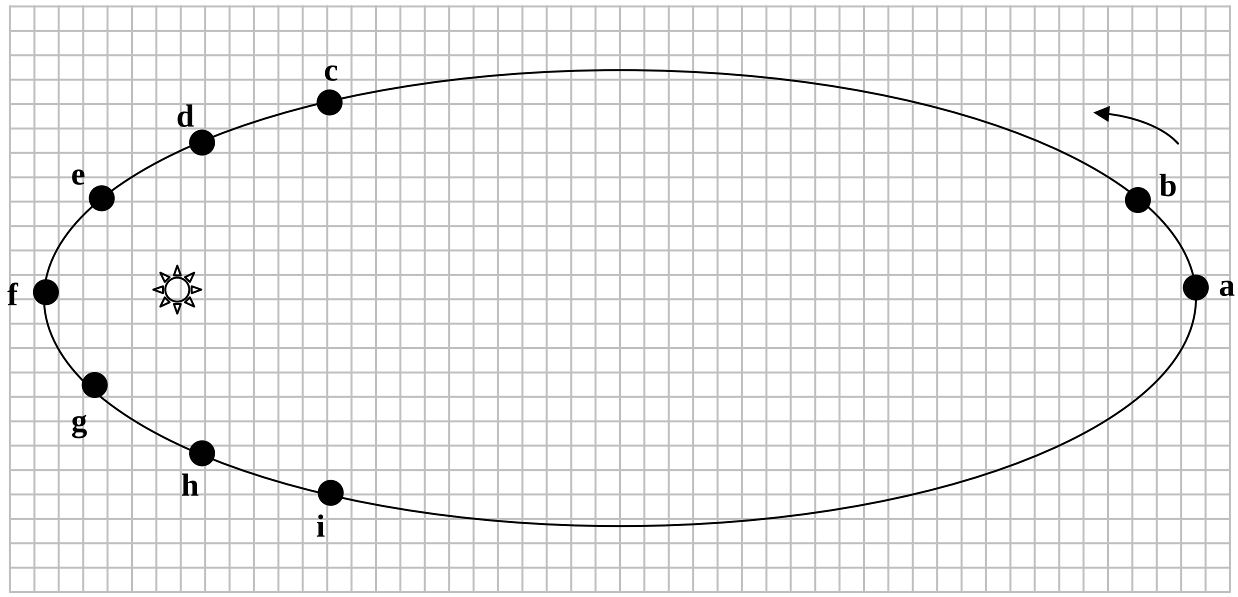
Imagine the situation shown at right in which a planet is moving in a perfectly circular orbit around its companion star. Note that the time between each position shown is exactly one month.



1. Does this planet obey Kepler's second law? How do you know?

2. If you were carefully watching this planet during the entire orbit, would the speed of the planet be increasing, decreasing or staying the same? How do you know?

In the drawing below, a planet that obeys Kepler's Second Law is shown at nine different locations (a-i) during the planet's orbit around its companion star.



3. Draw two lines: one connecting the planet at position "a" to the star and a second line connecting the planet at position "b" to the star. Shade in the triangular area swept out by the planet when traveling from positions "a" to "b".

4. Which other two planet positions, from those labeled c-i, could be used together to construct a second swept out triangular area that would have **approximately** the same area as the one you shaded in for question 3? Shade in the second swept out area using the planet positions that you chose. Note: your triangular area needs to only be roughly the same size, no calculations or quantitative estimates such as counting boxes is required.

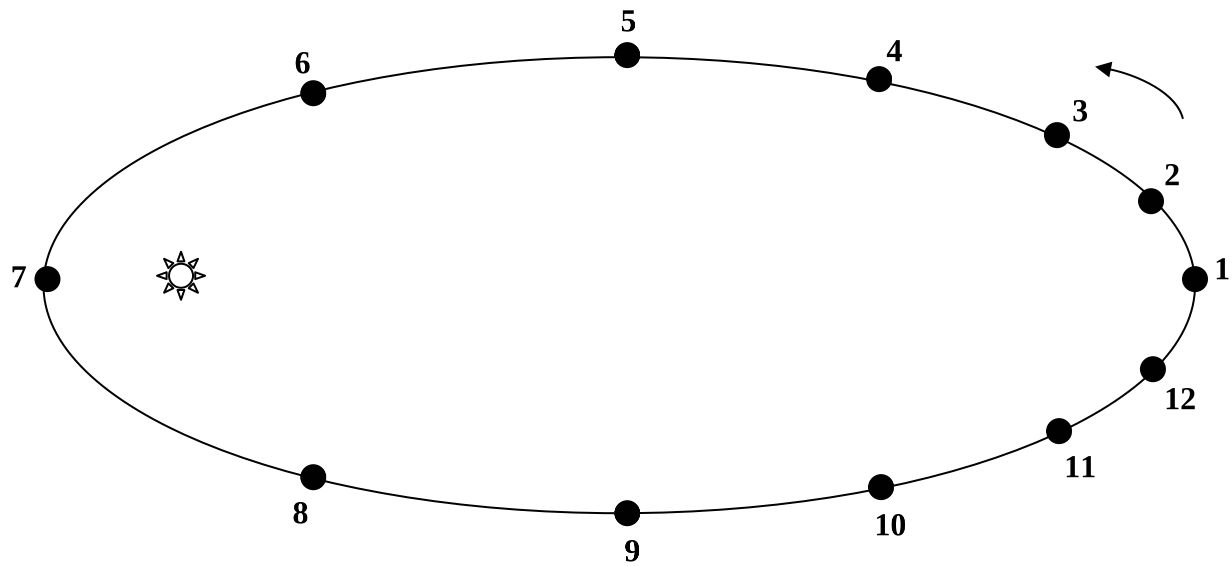
5. How would the time it takes the planet to travel from position "a" to position "b" compare (greater than, less than, or equal to) to the time it takes to travel between the two positions you selected in question 4? Explain your reasoning.

6. During which of the two time intervals, that you sketched the triangular areas for in questions 3 and 4, is the distance traveled by the planet greater?

7. During which of the two time intervals, that you sketched the triangular areas for in questions 3 and 4, would the planet be traveling faster? How can you tell?

II. Kepler's Second Law and the Speed of the Planets

The drawing below shows another planet's orbit. In this case, the twelve positions shown (1-12) are each exactly one month apart. As before, the planet shown obeys Kepler's Second Law.



8. Does the planet appear to be traveling the same distance each month?

9. At which position would the planet have been traveling the fastest? The slowest? How can you tell?

10. At position number 4, is the speed of the planet increasing or decreasing as time goes on? How can you tell?

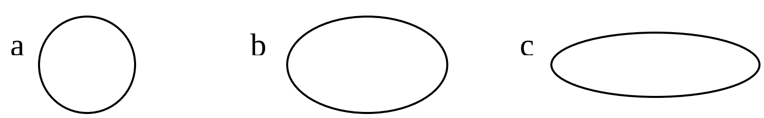
11. Provide a concise statement that describes the relationship that exists between a planet's orbital speed and the distance from its companion star.

III. Kepler's Second Law and Eccentricity

Consider the table below listing the eccentricity of the orbit for each planet in the solar system. Recall that an orbit with an eccentricity of zero is perfectly circular while the highly elliptical orbits shown in parts I and II would have a high eccentricity of approximately 0.90.

Planet	Eccentricity of Orbit
Mercury	0.206
Venus	0.007
Earth	0.016
Mars	0.093
Jupiter	0.048
Saturn	0.054
Uranus	0.047
Neptune	0.008
Pluto	0.248

12. Which of the three planet orbits shown below (a, b or c) would you say most closely matches the shape of Earth's orbit around the Sun? Explain your reasoning.



13. Which planets in the solar system would experience the largest change in orbital speed and which would experience the smallest change in orbital speed?

14. Describe the extent to which that you think Earth's orbital speed changes throughout a year? Explain your reasoning.